COLLIDER-ACCELERATOR DEPARTMENT

Title: Vacuum Lab Operations EMS Process Assessment

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Approvals

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BROOKHAVEN NATIONAL LABORATORY
PROCESS ASSESSMENT FORM

I. General Information

Process ID:	AGS-012-VLO		PEP ID # 012	
Process Name:	Vacuum Lab Operations			
Process Flow Diagrams:	AGS-012-VLO-01, -02, -03, and -04			
Process Description:	The process includes the Vacuum System Maintenance for the Alternating Gradient Synchrotron (AGS), Booster, TVDG, Linac and RHIC facilities. The vacuum system includes various large and small vacuum pumps. Periodically, this equipment is brought into Building 911A, and to a lesser extent into Building 820, to be serviced. Servicing includes replacing equipment fluids and worn parts, and inspecting the equipment to ensure that it is operating properly. The Vacuum Lab area in 911A is also utilized for the enamalization of flanges. A parts steam cleaner is available in Building 820 to clean and remove dust from parts in storage. Applicable subject areas include: Radioactive Waste Management, Hazardous Waste Management, and Liquid Effluents.			
Dept./Div.:	Collider-Accelerator Department			
Dept. Code:	AD			
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II. Detailed Process Descriptions and Waste Determination

Presently, the C-A Department has a major nuclear physics program, the focus of which is the Relativistic Heavy Ion Collider (RHIC) that operates to study nuclear phenomena in heavy ion collisions. The RHIC has four major RHIC experimental areas where ion beams collide: PHENIX PHOBOS, STAR and BRAHMS. However, the RHIC facilities are, in fact, the terminus of a complex of other accelerators and beam transfer equipment that also have experimental programs.

Located in the north central portion of BNL, the Collider-Accelerator Department is composed of seven accelerator physics machines including two Tandem Van de Graaffs (TVDGs), Linac, Booster, Alternating Gradient Synchrotron (AGS) and 2 rings in the Relativistic Heavy Ion Collider (RHIC). The TVDGs, Linac and Booster are considered pre-accelerators although they each have fixed target experimental programs. The TVDG and Linac supply low to medium energy particles to the Booster, which in turn accelerates and directs beam to AGS. The AGS is the heart of the high-energy system and it is utilized to produce or accelerate high-energy protons, polarized protons and heavy ions for use in various high-energy high-intensity experiments developed to study the fundamental characteristics of matter.

The TVDG has two experimental halls for applied nuclear physics research. The Linac supplies beam to fixed targets in the BLIP, which produces medical radioisotopes. The Booster supplies beam to fixed targets in the Booster Applications Facility, an experimental area that is used for space-radiation research. Two major experimental areas extend off the AGS: the slow extracted-beam (SEB) experimental area, and the fast-extracted-beam (FEB) experimental area, which are used for high-energy physics and proton radiography research.
. This process evaluation describes the maintenance of pumps that are used to create a vacuum in the beam lines of the TVDG, Linac AGS, Booster, and RHIC facilities.

The purpose of the vacuum system is to completely evacuate air from beam lines and cryostats. An ultra high vacuum is established in the beam line so that accelerated particles travel around the ring without colliding with atmospheric impurities (e.g., oxygen, nitrogen molecules, etc.), thereby allowing the maximum number of accelerated particles to be delivered to the target. The vacuum system includes various large and small vacuum pumps.

There are numerous turbo molecular (or “turbo”) vacuum pumps and portable turbo units within the beamline and experimental areas of the C-A Department. There are also numerous turbo molecular (or “turbo”) vacuum pumps and several large vacuum pumps. The large vacuum pumps are located in the blower stations A turbo molecular pump is a mechanical type of a vacuum pump where the gas molecules are pushed out by the action of fast moving surface. Momentum is imparted to the gas molecules by the fast moving rotor blades having a tangential velocity on the order of the thermal velocity of the gas molecules. Turbo molecular pumps are capable of evacuating a system from atmospheric pressure down to 10^{-8} millibars. They produce a clean and hydrocarbon-free vacuum..

Another type of vacuum pump called an ion pump supplements the turbo units. The ion pump has no moving parts and therefore no oils or other lubricants. The pump is started by applying high voltage between the pump's anode and cathode. Electrons are accelerated toward the positive anode by the magnetic field created. This has the effect of increasing the probability that an electron will collide with a gas molecule. The positive ions that are formed in the collisions strike the chemically active cathode "getter" plate. The ions combine with the cathode material and eject more cathode material which ends up on the surface of the anode. This constantly replenishes the film of the chemically active cathode material on the anodes which combines with active gas molecules and effectively removes them from the system.

Pumps called roughing (or "rough") pumps are used as an initial stage in creating an ultra high vacuum. They are used to reduce the pressure from atmospheric to a lower pressure level that the turbo units or ion pumps can then use. The roughing pumps are oil-filled.

In the case of mechanical pumps, oils, greases, and other residue will eventually evolve or desorb gases into the vacuum system, degrading system performance. In the case of ion pumps, build-up forms on the anode and cathode elements, degrading pumping efficiency. Mechanical cleaning, chemical cleaning or heat baking is required to eliminate these interfering residues. Vacuum system maintenance operations are performed in Building 911A, Room 144V and in Building 820 in the quonset hut area (for vacuum pump servicing) and front end of the large high-bay area (for steam cleaning). These operations include disassembly, oil drain and replacement, worn part replacement, bead blasting, baking, washing and reassembly.

<u>Regulatory Determination of Process Outputs</u>

1.0 Turbo, Rough and Blower Station Pump Servicing

The turbo, rough, and blower station pumps are brought to Building 911A and, occasionally, to Building 820 for servicing and oil replacement. When pumps are serviced in Building 820 spent vacuum oil is stored in a 5 gallon can which is transported to Building 911 where it is poured into the 55 gallon drum in the satellite hazardous waste collection area. After pump oil is removed, new oil is added. In addition to oil changes, parts such as o-rings and gaskets are changed as necessary. All spent o-rings, gaskets, wire, bolts, washers and other parts are segregated by material type for recycling and placed in collection containers in an adjacent satellite accumulation area in the Building 911 Vacuum Lab (1.1).

The satellite area has containers for plastics, metals, phenolics, industrial waste, radioactive parts and parts qualifying as mixed waste. Mixed waste generated by this operation includes parts which contain radioactive metals which are RCRA-listed such as silver or chromium-bearing (e.g., stainless steel) parts (1.2). Waste pump oil is stored in a single 55 gallon drum in the satellite area (1.3). Though not strictly required by Suffolk County Article 12, the drum rests on a secondary containment pallet. When full, the drum is sampled for radiological parameters and transported to the C-AD 90-day storage area. No radiological contamination has ever been found in this waste oil stream.

Any parts that are covered with oil and/or grease are degreased prior to disposal. Degreasing is performed by wiping with rags using LPS PreSolve or LPS Precision Clean citrus-based cleaners. Occasionally a degreasing tank in building 820 is used (this process is discussed

below). Empty aerosol cans are discarded in the regular trash (1.6). Spent oily rags are bagged, surveyed for radioactive contamination. If contaminated, they are disposed of as radioactive waste, otherwise, they are transferred to the Waste Management Division (WMD) for disposal as industrial waste (1.4). If the rags are neither contaminated nor oil-saturated, they are discarded in the regular trash (1.5). Metal parts are often wiped with lint-free paper and ethyl alcohol or acetone to remove fingerprints and prepare the items for baking and testing. These paper wipes dry quickly (during use) and are disposed of in the trash (1.5). The wipes do not meet the hazardous waste characteristic of ignitability when disposed. All chemicals utilized by the vacuum maintenance group are tracked using the BNL Chemical Management System (CMS). The CMS list of chemicals utilized by the vacuum maintenance group may be found at http://www.esh.bnl.gov/cms/. See also process flow diagram AGS-012-VLO-01.
A degreasing tank is located in the south portion of the Building 820. Occasionally this tank is used in the parts cleaning process. The part washing solvent 'Kustom' (manufactured by Certified Labs, Division of NCH Corp.) has been used in the tank. This solvent is an aliphatic petroleum distillate.

The solvent in this degreasing tank has not been replaced since the tank was installed in approximately 1991. The tank currently contains the solvent 'Kustom', a petroleum distillate based part washing solvent. After a part is removed from the tank, it is wiped with rags to remove any residual solvent. Spent rags are drummed and transferred to the HWMF for disposal as industrial waste.

There is some indication (old MSDS and labels) that the degreaser 'Saf-Sol' may have been used in this tank in the past. Saf-Sol is a mixture of aliphatic and chlorinated solvents. Since there is the possibility that this tank may contain a mixture of the two compounds, it is recommended that the tank be emptied, rinsed with clean 'Kustom' or 'A-151' and then refilled with one of these products. This will ensure wastes and rags associated with this part washer are not contaminated with the 'Saf-Sol' degreaser.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
1.1	Spent o-rings, gaskets, etc.	Non-hazardous, potentially radioactive solid waste as determined by process knowledge and radiological survey	Waste is segregated as low-level radioactive waste or discarded in the regular trash if not contaminated	None
1.2	Scrap metal	May be radioactive/ non-hazardous, non-rad/non-haz, non-rad/ haz or mixed solid waste as determined	Waste is segregated as scrap metal for off-site recycling if non-radioactive or disposed of as	None

		by process knowledge and surveys	mixed waste or LLRW, depending on material	
1.3	Spent vacuum pump oil	Non-hazardous liquid waste as determined by process knowledge	Waste is transferred to the satellite accumulation area and placed in a 55-gallon drum which is transferred to WMD for disposal as industrial waste when full	None
1.4	Oily rags	Non-hazardous solid waste , potentially radioactive as determined by process knowledge and radiation survey	Waste is bagged. Surveyed and sent to WMD for disposal as industrial waste or radioactive waste	None
1.5	Rags/paper wipes	Non-hazardous solid waste as determined by process knowledge	Disposed of in regular trash	None
1.6	Empty aerosol cans	Non-hazardous solid waste as determined by process knowledge	Separated and recycled	None
1.7	Spent solvent from Building 820 tank	Uncertain based on MSDS and labeling. Could be mixture of 'Kustom' (non-haz) and 'Saf-Sol' (MSDS lists chlorinated hydrocarbons, but not percentages)	Has not been disposed.	Pump out 820 parts washer tank and dispose as hazardous waste. Rinse with clean Kustom or A-151 and dispose. Refill with clean Kustom or A-151.

1.8	Spent rags	Non-hazardous solid waste as determined by process knowledge	Waste is drummed and sent to the HWMF for disposal as industrial waste	None
1.9	Solvent vapors	Non-hazardous vapors as determined by process knowledge	Vapors are released to ambient air	None

2.0 Ion Pump Servicing

Unlike the turbo and rough pump, the ion pump has no moving parts and, therefore, no oil or other lubricant wastes. However, build-up on the anode and cathode elements must be periodically removed. This is done by disassembling the pump, transporting the elements to the bead blaster unit for abrasion and baking the elements in an oven to force embedded material to outgas from the elements. Parts are baked at 700° C for up to 24 hours. There are no atmospheric emissions from the baking which would require a New York State air permit.

The beads in the blasting unit are made of aluminum oxide and are changed out once or twice annually. The beads are surveyed for radioactivity prior to disposal and are often found to be contaminated. When this happens, they are disposed of as low-level radioactive waste (LLRW), otherwise, they go to regular trash (2.1). Since many of the elements which come from these pumps have been exposed to secondary radiation around the beam lines, particulate flakes generated during disassembly are radioactive. They are vacuumed up using a "hot-vac". The C-AD health physics group monitors the hot-vac contents and labels it as LLRW (2.2). The bead blaster unit has no direct exhaust to the atmosphere and does not require a New York State air permit to operate. A process flow diagram is presented in AGS-012-VLO-02.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
2.1	Aluminum oxide beads	Radioactive or non-radioactive based on direct analysis	Disposed to regular trash if clean, or rad waste if radioactive	None
2.2	Hot vacuum contents	Radioactive or non-radioactive based on direct analysis	Disposed to regular trash if clean, or rad waste if radioactive	None

3.0 Parts Washing

Some metallic vacuum system parts are washed in a high temperature washing machine using Alconox.. Rinse water from the washing machine has been analyzed for heavy metals by the Toxicity Characteristics Leaching Procedure (TCLP). All parameters were found to be less than the Sewage Treatment Plant SPDES permit limitations. Previous testing has shown no radiological contamination in this waste water. The rinse water from the washer goes to a holding tank which can be discharged to the site sanitary system (3.1).

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
3.1	Washer rinse water	Non-radioactive, non-hazardous by direct analysis	Disposed of to sanitary system	None

4.0 Miscellaneous

- Compressed nitrogen gas is used as a pressure supply for valve testing or for spraying off parts. Compressed helium gas is used for leak checking vacuum systems. Gases are released directly to the atmosphere (4.1). Empty gas bottles are returned to the supplier (4.2).
- Tin foil is used extensively in the vacuum shop to cover cleaned parts to prevent contamination while in storage before reinsertion into the system. Used tin foil is disposed of in the regular trash (4.3).
- Enamalization is performed on flanges to coat them for electrical isolation. The enamel is a ceramic material which is applied in a spray-on liquid form inside a hood. The coated parts are baked at 900° C in an oven in the vacuum lab clean room. No air permit is required for this operation. Empty enamel containers are collected and segregated for recycling (4.4).
- Some parts soldering is performed in the lab using silver solder. Solder scraps collected and segregated for recycling (4.5).

A process flow diagram for these items is presented in AGS-012-VLO-03.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
4.1	Helium, nitrogen gas	Non-hazardous / process knowledge	Released to ambient atmosphere	None
4.3	Empty compressed gas cylinders	Non-hazardous / process knowledge	Returned to the supplier	None
4.3	Used tin foil	Non-hazardous / process knowledge	Disposed of in regular trash	None
4.4	Empty enamel containers	Non-hazardous / process knowledge	Disposed of in regular trash	None
4.5	Solder tailings	Hazardous if it contains silver / process knowledge	solder & tailings are sent to recycling or disposed of as hazardous waste	None

5.0 New Parts Steam Cleaning Operation

In the past, new parts for the vacuum system have been delivered to Building 820 for storage prior to installation. While in storage, the parts were steam cleaned to remove dust that may have accumulated during shipping. The new parts steam cleaning operation was conducted in the large high-bay area within Building 820, as well as outside of Building 820. This capability exists and is part of the Vacuum Maintenance operations but is only used on an occasional basis. Currently the steam cleaner is “locked out” and has a yellow “Do Not Operate” tag is affixed to it.

When used, parts are steam cleaned on spill pallets that are designed to contain all rinse water. Biodegradable soap and water are utilized during cleaning. The steam cleaner is powered by kerosene. The rinse water is discharged to the sanitary sewer system. Following steam cleaning, the open ends of the parts are wrapped in aluminum foil to prevent dust from accumulating. Clean parts are returned to storage until such time as they are installed in the vacuum system.

A process flow diagram for these items is presented in AGS-012-VLO-04.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
5.1	Steam cleaning rinse water	Non-hazardous liquid waste as determined by process knowledge	Waste is discharged to the sanitary sewer system	None
5.2	Steam cleaner engine exhaust	Non-hazardous emission as determined by process knowledge	Waste is released to outside air	None
5.3	Non-oil-contaminated rags and empty chemical/ cleaner containers	Non-hazardous solid waste as determined by process knowledge	Waste is discarded in the regular trash	None

III. Waste Minimization, Opportunity for Pollution Prevention

During the initial effort of baselining the Collider-Accelerator Department processes for Pollution Prevention and Waste Minimization Opportunities each waste, effluent, and emission was evaluated to determine if there were opportunities to reduce either the volume or toxicity of the waste stream. Consideration was given to substitute raw materials with less toxic or less hazardous materials, process changes, reuse or recycling of materials and/or wastes, and other initiatives. These actions are documented in this section of the original process evaluation. Action taken on each of the Pollution Prevention and Waste Minimization items identified can be found in the Environmental Services Division’s PEP 2000 Database. Further identification of Pollution Prevention and Waste Minimization Opportunities is made during an annual assessment of C-A processes. If any Pollution Prevention and Waste Minimization Opportunities are identified they are forwarded to the Environmental Services Division for tracking through the PEP Database.

IV. Assessment Prevention and Control

During the initial effort of baselining the Collider-Accelerator Department Assessment, Prevention, and Control (APC) Measures operations, experiments, and waste that have the potential for equipment malfunction, deterioration, or operator error, and discharges or emissions that may cause or lead to releases of hazardous waste or pollutants to the environment or that potentially pose a threat to human health or the environment were described. A thorough assessment of these operations was made to determine: if engineering controls were needed to control hazards; where documented standard operating procedures needed to be developed; where routine, objective, self-inspections by department supervision and trained staff needed to be conducted and documented; and where any other vulnerability needed to be further evaluated.

These actions are documented in this section of the original process evaluation. Action taken on each of the Assessment, Prevention and Control Measures can be found in the Environmental Services Division's PEP 2000 Database. Further identification of Assessment, Prevention and Control Measures are made during an annual assessment of C-A processes. If any Assessment, Prevention and Control Measures are identified, then they are forwarded to the Environmental Services Division for tracking through the PEP Database.